

7.6 feet above at Wenatchee, Wash. The mean stage was 0.5 foot lower than in March at Vancouver, 2.4 feet higher at Umatilla, and 8.1 feet higher at Wenatchee. At Vancouver the river rose from 9.5 feet on the 7th to 16.9 feet on the 30th, at Umatilla from 10.4 feet on the 7th to 18.1 feet on the 30th, and at Wenatchee from 13.0 feet on the 12th to 27.3 feet on the 30th. At the end of the month the annual rise of the Columbia is well under way. While the water is at a stage where much damage might have been done, warnings have been issued ever since the rapid rise began with the result that, so far, no losses have been reported and all parties interested are being notified of probable future stages by means of telephone, river bulletins, and the river forecasts that are being published in the daily papers.

The Snake River.—The mean of the daily stages, at the various stations, for the month, was about the same as for March, but from 3.0 to 5.0 feet above the normal for April. The water was at its lowest on the 6th and at its highest on the 30th. At Lewiston, Idaho, it rose from 9.3 feet on the 6th to 15.6 feet on the 27th. The Snake River was navigable to freight and passenger boats as far up as Asotin, Idaho.

The Willamette River.—The mean stage ranged from 0.4 foot below the normal at Eugene to 2.0 feet below at Albany and Salem, but at Portland, where the stages were determined by the height of the Columbia, it was 2.8 feet higher than usual for this period. The stage of the Willamette averaged generally about 3.0 feet lower than for March of this year. Except at Portland, where they were about the same as at Vancouver, the daily stages at the reporting stations varied little from the mean stage for the month which was 5.0 feet at Eugene and about 4.0 feet at Albany and Salem. The only rains in the valley that were sufficiently heavy to affect the run-off occurred from the 7th to the 12th.

MISCELLANEOUS PHENOMENA.

The prevailing winds were from the southwest. There was an excess of sunshine, except in western Washington where the amount fell slightly below the normal. The percentage of possible sunshine was 63 at Spokane, 39 at Seattle, and 55 at Portland. Killing frosts were general on the 14th and 28th; vegetation, however, was in excellent condition at the close of the month. Thunderstorms accompanied by hail were reported at many stations on the 2d and 10th. Several forest fires occurred in Washington during the latter part of the month. There were no very high winds reported.

A light earthquake shock was noted at Anaconda, Mont., on the 19th, about 1:30 a. m.

SNOWFALL CONDITIONS AND THE PROSPECTIVE WATER SUPPLY; UPPER COLUMBIA RIVER.

Bitterroot Basin.—The flow of water during April was greater than normal; it had begun to decrease at the end of the month. The stock of snow in the higher mountains is reported materially depleted and the prospect for a normal water flow later in the season is quite unfavorable.

Flathead Basin.—Stream flow below normal during April and decreasing at the close of the month. The indications are that the later run-off will be below normal, as the snow in the high mountains has been reduced by the warm weather to such an extent as to probably lessen materially the late flow of water.

Missoula Basin.—Reports are unfavorable, except in the vicinity of Elliston. In general the April flow was above normal and the snow supply was depleted by the warm weather.

Deer Lodge.—The stock of snow has been materially reduced and, unless there is a great deal of snow and rain in May and June, all the streams will be below normal.

Deborgia.—There will not be the normal flow of water this season unless supplemented by rain. Snow going very fast and the quantity much less than in former years.

Elliston.—Stream flow about normal, decreasing at end of month on account of the cold weather. The stock of snow has been reduced somewhat, but there is more left on the mountains than at this time last year. There will be above the normal water flow the remainder of the season, because of the greater amount of snow, due to there being no rains this spring to start the snow and the springs.

Clarke Basin.—Conditions are very favorable for normal waterflow. The amount of snow on the Divide north of the Clarke is reported to be much above normal.

Nixon.—The stock of snow has not been depleted by the warm weather. Owing to the solid condition of the snow and the amount in the higher ranges the prospect for a good supply of water is excellent.

Thompson.—The stock of snow in the high ranges has not been depleted and there seems to be an unusual amount in these regions. The flow of water should therefore be normal for the rest of the season.

IRRIGATION PROJECT IN EAGLE AND PINE VALLEYS, OREGON.

Mr. E. M. Blake, general manager of the Eastern Oregon Irrigation Company, furnishes the following information regarding the scope of the work to be undertaken by his company in Baker County, Oreg., during the coming summer. This project has been approved by the State engineer, and it is being financed by people living in Chicago, Cleveland, and Boise:

The irrigation project being undertaken by the Eastern Oregon Irrigation Company comprises about 22,000 acres of desert lands, which have been segregated under the terms of the Carey Act, in townships 8 and 9 south, ranges 45, 46, 47, and 48 east of the Willamette meridian. In addition to this Carey Act land about 7,500 acres of private lands, held under the terms of the Desert and Homestead Acts, come under the canal and will be watered by the company. Most of this land is side-hill land, especially adapted to the successful raising of fruit for which the two valleys are already noted. Some of the slopes are as high as 30°, but the nature of the soil is such as to prevent erosion even on these steep slopes, and already there exist high-grade orchards in the valleys on slopes as steep as this. The soil is a basaltic and volcanic ash with just a slight admixture of clay, and when irrigated is as fertile as any soil to be found in the northwest.

The company proposes to construct a concrete diversion dam across Eagle Creek at a point in section 27, township 7 south, range 44 east of Willamette meridian. From this point the canal will follow the east side slopes of the Valley of Eagle Creek for a distance of about 9 miles before reaching the first of the lands to be irrigated, continuing on to cover approximately 30,000 acres of land in Eagle and Pine valleys. The details of construction cover several siphons, some fluming, and possibly one or two tunnels if distance can thereby be shortened, which will be determined as soon as the final surveys can be completed. In all there will probably be about 23 miles of main canal.

The drainage area above the point of diversion covers the watershed of the Granite Mountains and the high hills and mountains of the Sanger, Sparta, and Cornucopia mining districts, running up to the Divide between Eagle Creek and the Imnaha River. The exact area of this watershed has never been determined, but it is approximately 150 square miles. The average annual rainfall, so far as it can be stated from the available data, is about 16 inches, but this is mostly in the form of snow which does not melt until very late in the season. In fact, Eagle Creek keeps up its large flow until late in July of each year, storage being required for a period of only about 30 days. The percentage of run-off to rainfall is very high and Eagle Creek is known as one of the best and most constant streams in the State. The State engineer is at the present time making a water survey of all lands watered from Eagle Creek by arrangement with this company. This will be the first step in adjudicating the water rights on Eagle Creek in order that the company may determine accurately how much storage must be provided. Storage sites exist above the points of diversion which will be surveyed this spring, probably in conjunction with the surveying party of the State engineer.

COOPERATIVE INVESTIGATIONS OF WATER SUPPLY AND ITS RELATIONS TO THE DEVELOPMENT OF CENTRAL OREGON.

By J. C. STEVENS, District Engineer, U. S. Geological Survey.

Central Oregon has long held the distinction of being the largest area in the United States without railroad transportation. The present indications are that this distinction will not attach to it much longer.

The latent resources of this large area are fast attracting the attention of homeseekers and those desiring to invest in the development of these resources. Perhaps the most important development will be along agricultural lines. The territory is an arid one, and irrigation is necessary. While there is a considerable area that can be utilized for profitable development under dry farming processes, the crops resulting from irrigated agriculture will far exceed those from the dry farms.

The water supply of this territory is distributed with no degree of uniformity. There is a comparatively small area that can be irrigated by individual effort. On the other hand, there are large areas that can be irrigated as community enterprises. Under the provisions of the Carey Act large areas are already in a state of development by corporations who have contracted

with the State for this work. These, of course, cover Government or State lands. In other sections there are favorable opportunities for irrigation of lands already in private ownership. Such enterprises will require an investment of comparatively large amounts of capital. Heretofore such investments have not been profitable because of the lack of railroad transportation. There was no incentive to invest in the irrigation of lands, no matter how productive those lands might be, unless means were provided whereby the crops raised could be transported to market. The present prospects, however, for railroad extension into this territory places these projects in an entirely new light, and the development that is sure to follow the construction of railroads will far exceed our fondest hopes.

In all cases the one feature that determines the feasibility of these projects is that of water supply. The physical difficulties involved in the construction of dams, canals, and other irrigation works can be easily overcome, but the determination of water supply involves the element of time to such an extent that the problems connected therewith are not so readily solved.

The water to be utilized on the land is to be drawn from the streams. In nearly every case the entire yield of the drainage area must be utilized in order to furnish a sufficient amount for the lands that lie favorably for irrigation from them. This requires an extensive development of storage reservoirs. In nearly every case the amount of land that can be reclaimed is dependent solely upon the amount of water that can thus be rendered available for this purpose. The necessity, therefore, of securing reliable water supply data can not be too strongly urged. The determination of this important feature involves careful measurement of all the streams in the territory and a determination of the actual amount of water flowing each day in a year. The relation which stream flow bears to the rain and snow fall makes it necessary to study exhaustively the climatic conditions that obtain here. In this country the inhabitants are so scattering that it is almost impossible to secure local observers of rainfall, temperature, or of river gage heights at the points desired. In the determination of rain and snow fall, observations should be made at the higher altitudes. In these localities no inhabitants are found. The selection of rainfall stations, therefore, has been governed by the facilities for securing observations rather than by physical requirements.

In 1903 the United States Reclamation Service instituted an investigation of the water supply for certain projects that were then under consideration. It was found that the knowledge required to determine the feasibility of these projects was entirely inadequate, and that nothing definite could be done toward construction work until more information on the available water supply could be secured. Funds, however, were not available for a continued study of the streams necessary, and only a few of the more important stations were maintained.

In 1908 a systematic study of the water supply of central Oregon was undertaken by the United States Geological Survey in cooperation with the United States Reclamation Service, the United States Weather Bureau, and the State of Oregon. An engineer was put into the field to install rain and snow fall stations and gages at desired points on the streams of the territory. The determination of stream discharge requires frequent visits to these stations. At every visit measurements of discharge are made by means of a current meter. When these measurements or gagings cover a sufficient range in the stage of the streams, rating tables for each station can be prepared that will indicate the discharge in cubic feet per second for every stage of the river as indicated by the gage. Since gage readings are secured every day by local parties, it is thus possible to determine the discharge every day. The results of these investigations appear in the annual publications of the United States Geological Survey. Those for 1903 will be found in Water Supply Paper No. 100; those for 1904 in Nos. 133, 134,

and 135; those for 1905 in Nos. 176, 177, and 178; those for 1906 in Nos. 212, 213, and 214; and those for 1907-8 in Nos. 250, 251, and 252. Of the last 3 papers, only No. 252 has as yet appeared in print.

The records obtained at the rainfall stations are published in the periodic reports of the United States Weather Bureau. Since July, 1909, these will be found in the MONTHLY WEATHER REVIEW and in the separates of the 12 districts into which the United States has been divided for this work.

In addition to these rainfall and stream flow stations, a limited amount of data on the evaporation from water surfaces was secured. Evaporation pans were installed in Harney Lake, Christmas Lake, and in Klamath River. While these data are meager, incomplete, and widely scattered, they nevertheless furnish some very necessary information when investigating the feasibility of storage projects.

The funds available for these investigations of water supply have not been commensurate with the necessity for the data, and on this account it has been necessary to spread the limited funds over a wide expanse of territory. Were it not for the cooperative agreements between the organizations above mentioned, investigations would not have been possible. The United States Geological Survey, through its engineers, secure data in the field, and analyze and publish them. The United States Reclamation Service pays one-half the cost of field examinations for the investigation of stream flow. The United States Weather Bureau has equipped with meteorological instruments, and furnished and paid observers for precipitation stations, and has compiled, analyzed, and published rainfall and snowfall data. The State of Oregon, through its State Engineer, is cooperating with the United States Geological Survey in securing stream-flow data in the State. There is available each year by legislative appropriation \$2,500 for this cooperation. This money is expended under the direction of the United States Geological Survey, a portion thereof being used for the investigations in central Oregon.

In addition to the Government bureaus engaged in this cooperative work, the support of a number of irrigation and power companies in the territory has been enlisted. In this manner gage observations at many of the stations have been secured. At other points rainfall and snowfall data are being furnished voluntarily. No better plan of securing scientific data of this nature can be devised than that of hearty cooperation between all parties interested. In this work the State is probably the chief beneficiary. The Government's interest lies in the fact that the development of these nonproducing areas add homes to our civilization.

IRRIGATION IN THE WILLAMETTE VALLEY.

By JOHN H. LEWIS, State Engineer.

For many years grain growing has been the leading industry of the Willamette Valley, all of which is in private ownership. The average farm is probably 640 acres in extent, the tendency being to increase, rather than decrease, such area, because of the diminished yield to constant cropping. Diversified farming has been urged of late as a remedy, but this is possible only on selected lands which are retentive of moisture, or those which receive moisture through subirrigation. It is not contended that irrigation is necessary for all crops, for deep-rooted plants such as orchards are not affected by the long, dry summer. But for truck garden, alfalfa, clover, small fruits, and vegetables, irrigation in reasonable quantities is absolutely necessary for the highest yield.

Dairying is destined to become the leading industry of the valley, because of the mild, open winters. The most serious obstacle, however, is the long, dry summer, when it is necessary to carry the herd on dry feed, the same as during the winter months in the East. This condition, however, can easily be remedied through the artificial application of moisture. It has